"ELECTRICAL PROTECTION AT SUBSCRIBER STATIONS"

CONTENTS

1. GENERAL

1.1 This section provides REA Borrowers, consulting engineers, contractors, and other interested parties with technical information for use in the design, construction and operation of REA Borrowers' telephone systems. This section includes an outline of station protection principles; application and installation of subscriber station protectors and applicable grounding techniques to be employed at telephone station installations. Supplemental information with respect to subscriber station protection is included with TE & CM-701, "Station Installations," and TE & CM-830, "Electrical Protection Assembly Units."

1.2 This revision replaces Section 805, Issue 6, dated July 1969, and incorporates parts of Addendum 1 to Issue 6, dated January 1974; cancels the provisions of Addendum 1 to Issue 6 pertaining to the requirement that "gas pipes and other metallic parts within reach of the person using the telephone" should be included in the common grounding system. It further clarifies the paragraphs pertaining to station protection principles and methods. Details of grounding and bonding rules are also revised and clarified.

1.3 In order to limit hazards which occur as a result of power circuits and lightning, suitable protectors are required at all subscriber stations. This rule applies whether the stations are served by aerial or buried plant. All station protector installations must comply with applicable requirements of the National Electrical Code (NEC), and applicable local codes.

2. PROTECTION PRINCIPLES

2.1 Disturbing Potentials: Subscriber stations are subjected to abnormal voltages and currents caused by (1) lightning surges and (2) contacts between telephone outside plant conductors and power distribution conductors, or by induction from such power circuits.

2.11 Lightning surges comprise the bulk of these abnormal potentials and may be (1) conducted to the station by the outside wire or cable or (2) they may be produced by a potential rise at the station protector ground electrode due to a nearby stroke. Lightning surge currents conducted to the station by outside plant wire or cable are not necessarily the result of a direct stroke to the outside plant but may arise from electromagnetic and/or electrostatic induction from the stroke.

2.12 The use of all-buried telephone wire or cable (i.e., circuits buried throughout their entire length) eliminates the likelihood of contact with power conductors except in rare instances in the joint use of trenches at random separation from buried power conductors.

2.2 Objectives: The objectives in the provision of protective measures at subscribers' stations are: (1) the prevention of electric shock to the telephone user and fire hazard to his premises; and (2) the assurance of service continuity by protecting the telephone equipment and wiring against dielectric failure and overheating.

2.3 Methods: The basic principles applicable in the prevention of harmful potentials at telephone subscribers' stations are two fold: (1) the diversion to earth of lightning and power currents appearing in the connecting telephone wire or cable plant by the use of appropriate arresters at the station; and (2) the prevention of harmful potentials from developing between the three major station utilities connected to earth, by the common grounding[1/] of these systems. The three utilities requiring common grounding are: (1) the telephone system, (2) the power system, and (3) water pipe system. Hardware associated with all of these systems are handled regularly by customers and the development of excessive voltages between them, representing a serious shock hazard, can be prevented only by common grounding. The grounding electrodes of all three of these systems must be bonded together in all installations regardless of the type of water system; this must be done whether or not the water system is considered to be a "good" (low resistance) ground or not, and is necessary whether or not the water pipe system is partly comprised of plastic pipe.

1/ "Common grounding" means the interconnection of the power system ground, the water system, and the telephone protector ground.

Additional information on grounding details is covered under Paragraph 5, and in TE & CM-802. Figure 1 illustrates how a lightning surge arising in either the telephone or the power system easily produces hazardous potentials where these three grounded systems are not interconnected.

3. STATION PROTECTORS

3.1 Fuseless Type

3.11 Fuseless type protectors are preferred because they provide more effective protection than fused types. Their use is controlled by rules of the NEC as covered under Paragraph 3.13.

3.12 The fuseless protector employs white coded (350 to 600V) air-gap or equivalent lightning arresters connected between each line conductor and ground. These arresters have a breakdown value adequate for the protection of personnel and well below the dielectric strength of station apparatus and wiring. The protector is designed to have a current-carrying capacity in excess of that of the 19-gauge copper wire or cable pair with which it may be associated. The use of fuseless protectors is desirable because a ground on the power line is maintained in the event of a contact, thereby aiding in deenergizing the power circuit. Elimination of fuses also prevents excessive potential on the drop wire or at the protector terminals after fuse operation in the event of a power contact, and results in a reduction in station maintenance visits.

3.13 The NEC requires the use of "approved" insulated conductors in the form of drop wire or cable between the last outdoor support and the station protector. It also requires "approved" protectors and "approved" ground wire. The word "approved" commonly means acceptance for listing by Underwriters' Laboratories, Inc. The rules applying to the use of fuseless station protectors at stations served by drop wires require that in the event of a power contact to an outside plant conductor, the station drop wire, protector, and grounding conductor must be safeguarded against fire hazard by the fusing of a conductor not appearing at the station premises. Such conductors may be in the form of supplementary fusible links between the wire or cable plant and the station drop, or they may be the outside plant wire or cable conductors themselves. When cable is used between the last outdoor support and the station protector, the effectively grounded metal shield is primarily relied upon to prevent fire hazards. Present designs of multipair distribution wire (MPDW) must <u>not</u> be used between the last outdoor support and the protector. MPDW does not qualify as a cable because of the lack of a metallic shield, nor does it qualify as "approved insulated conductors" because it does not meet flame resistance requirements.

3.131 Fuseless protectors may be used at stations served by metal shielded aerial cable; i.e., cable conductors connected directly to station protector terminals, provided the cable shield is effectively grounded and the cable conductors are of copper and are 19-gauge or smaller, or have equivalent conductivity.

3.132 Fuseless protectors may also be used at stations served by drop wires from aerial cable under the following conditions: (1) the cable shield is effectively grounded; (2) where parallel-type drop wire 2/ is used and either (a) the cable conductors are no larger than 24-gauge copper or (b) 24-gauge copper fuse links are inserted between the cable conductors and the drop wire.

3.133 Fuseless protectors may be used at stations served from non-cable type facilities 3/ under the following conditions: (1) the protector ground connections must be made to a continuous metallic water pipe system having at least 10 feet of buried pipe and/or to an MGN 4/ grounding conductor or ground electrode; and (2) where parallel-type drop wire is used, a fusible link of 24-gauge copper or 20-gauge, 30 percent conductivity copper-steel bridle wire is inserted between the drop wire and the noncable plant. If it is not practicable to fulfill the above conditions, the fused-type protector must be used. Every effort should be made to avoid resorting to fused-type protectors because of the inferior protection they render as compared with properly installed and grounded fuseless protectors.

3.134 Fuseless protectors should be used at stations served from all-buried circuits, i.e., circuits that are buried throughout their entire length and are, therefore, not exposed to power contacts and on circuits that are all buried except for an aerial drop at the subscriber's premises. No fuse links are required in such circuits. Fuseless station protectors should also be used at all stations served from (1) buried pairs which appear in exposed aerial inserts and/or (2) buried pairs which are extended by exposed aerial facilities other than short drop wire. In these cases, the station protectors must be isolated from the exposed sections of the circuit by suitable fuse links in accordance with REA TE & CM-816, "Electrical Protection of Buried Plant." Also, where buried pairs are extended by aerial noncable-type facilities, the grounding provisions of Paragraph 3.133 must be met at each station where a fuseless protector is used.

3.135 In the proper application of REA construction practices, fuseless protectors should always be used except at stations served from non-cable-type facilities having protector grounding electrodes which do not meet the requirements described in Paragraph 3.133.

2/ 18 Gauge 30% copper-steel conductors.

3/ The term "noncable type facilities" means conductors which are not enclosed in a grounded metal shield. This includes open wire and MPDW.

4/ The term "multigrounded neutral" (MGN) refers to the neutral conductor of a wye-connected electrical supply system where the neutral conductor has at least four ground connections in each mile of line in addition to the ground connections at individual services, and where the primary and secondary neutrals are solidly interconnected.

3.2 Fused-Type

3.21 Fused-type station protectors employ white coded (350 to 600V) air-gap or equivalent lightning arresters for the limitation of excessive potentials, and fuses to limit sustained currents to a value the protector can safely carry (15 amperes per conductor continuously for most types of fused protectors.) The fuses are required to open the circuit on currents resulting from power contacts which would otherwise result in a fire hazard because of overheating the protector. One fuse is connected in each side of the line on the line side of the arrester.

3.22 With the fused type of protector, the ground connection for the drop wire is lost when the fuses operate, and the drop wire and the protector line terminals may, therefore, remain energized at an excessive potential. For this reason, and because they are subject to high maintenance, fused protectors are not recommended, and their use should be avoided except where the requirements for fuseless protectors cannot be met.

3.3 Gas Tube Type

3.31 Gas tube station protectors which appear on the REA "List of Materials Acceptable for Use on Telephone Systems of REA Borrowers", may be used in place of air-gap type fuseless station protectors described in Paragraph 3.12 provided all requirements for the use of fuseless station protectors are met. Gas tube station protectors have a higher initial cost. Therefore, they are not recommended except in severe lightning damage areas where maintenance of carbon gaps is a problem. See TE & CM-823, "Electrical Protection by Gas Tube Arresters", for further discussion of gas tubes.

4. PROTECTOR INSTALLATIONS

4.1 In planning and staking station installations the selection of the protector location should be made with primary emphasis on the achievement of common grounding of the telephone protector with the power system ground and the water system as indicated in REA TE & CM-701. See REA Standard PC-5 "Station Installations" for installation details.

4.2 Outdoor-type station protectors are preferred for the large majority of installations in REA Borrowers' telephone systems because of their accessibility for maintenance and testing purposes. Inside mounted protectors are only desirable in areas where severe atmospheric corrosion occurs, such as in salt or sulphur-bearing atmospheres.

4.3 Outside mounted multipair fuseless station protector assemblies of 2 to 6 protectors are now available and are recommended instead of multiple installations of single-pair protectors on buildings served by 2 to 6 lines. Inside mounted multipair fuseless protector assemblies expandable from 2 pairs to 36 pairs are also available and are recommended where a number of stations are served from a cable brought directly into the building. Electrically, each protector unit is equivalent to a single pair fuseless station protector. See REA Standard PC-5 for installation details.

5. PROTECTOR GROUNDING AND BONDING--FIXED INSTALLATIONS

5.01 Copper has been found to be the most satisfactory material for bonding and grounding conductors and its exclusive use has been assumed throughout this section. If it becomes necessary to substitute another material for copper, specific measures not covered herein, will be required to insure equivalent conductivity, adequate resistance to corrosion, and proper installation and termination. No substitution of another material for copper should be made without first obtaining specific instructions from REA for use of the substitute material.

5.02 As indicated in Paragraph 2.3, it is essential that the power and communication ground systems at the subscriber's station be connected to each other and to the water piping systems in order to avoid dangerous voltage differences within the subscriber's premises. This is essential whether or not such piping systems meet minimum requirements, are preferred grounding electrodes and whether or not the telephone line facilities are buried. A low resistance ground is desirable in that it aids in assuring deenergization of the power system in the event of a contact; also, a low resistance ground is beneficial in minimizing the development of excessive potential differences between systems, but it is not a substitute for potential equalization by common grounding.

5.03 Preferred Grounds: Every effort should be made to use the ground electrodes described below in (a), (b), or (c), because they achieve common grounding; and they also usually result in the lowest practicable ground resistance. These grounding systems, in order of preference, are as follows:

(a) Continuous metallic underground community water system to which the power service is grounded.

(b) Power service multigrounded neutral (MGN) ground interconnected with local continuous underground metallic water system, having at least 10 feet of buried metallic pipe.

(c) Power service ground other than MGN interconnected with local continuous underground metallic water system having at least 10 feet of buried metallic pipe.

5.04 Other Grounds: The grounds described in (a), (b), or (c) and (d) below are inferior and reduce personal safety since they do not fully accomplish common grounding:

(a) Power system MGN ground alone, or

(b) Local water system with 10 feet or more of buried metallic pipe alone, or

(c) Ground rod interconnected with local water system not meeting the requirements of 5.04(b).

(d) Ground rod interconnected with driven electric service ground rod on a non-MGN type power system.

5.05 Ground rod or rods not interconnected with either water or electric service ground: Use of a ground rod as the only station protector grounding electrode is acceptable only when a station has no internal metallic water pipe and no electric service. In all other cases, it is essential that all of the ground electrodes be interconnected whether or not any or all of these are "low resistance" grounds. This is necessary since the passage of lightning surge currents into a ground electrode which is not interconnected with the other grounded facilities, develops hazardous voltages to other grounded systems not interconnected to the same ground electrode. These voltages may readily constitute a fatal shock hazard to the telephone user.

5.06 Applications of essential protection principles to stations having all-plastic water pipes present problems requiring continuing study. Accessibility of metal components of such installations for interconnection with power and telephone grounds may be limited. However, the elimination of hazardous potential differences between these three systems through common grounding is very important. The fact that a water column comprises the path to earth, if common bonding is not employed, in a case of personal contact cannot be relied upon as having sufficient impedance to limit shock currents to safe values. Therefore, a serious effort should be made, such as metal couplings, unions, outside taps or hot water pipes (which are not usually plastic).

5.07 Detailed information concerning available grounding units and their order of preference for the combinations of grounding conditions most likely to be encountered can be found in Table 3 of REA TE & CM-701.

5.08 Grounding conditions from telephone protectors to the various grounding electrodes listed in Paragraph 5.03 and 5.04 should be as shown in the following table, using insulated copper wire.

TABLE 1

GROUNDING ELECTRODES AS IN		GROUNDING WIRE GAUGE: SINGLE PROTECTOR	GROUNDING WIRE GAUGE: 2 OR MORE PROTECTORS
Paragraph 5.03	a	14	10
	b	14	10
	c	14	10
Paragraph 5.04	a	14	10
	b	14	10
	c	6	6
	d	6	6

5.09 Wherever separate ground rods are used for both the telephone and electric systems, they should be bonded together with a #6 or larger copper wire. If these rods are of dissimilar metals, corrosion may be a problem, as discussed in TE & CM-802.

5.10 Where conditions are such that the preferred location of the telephone protector is on the opposite side of the house from the electric service ground and a metallic water pipe system exists, interconnection may be accomplished by (a) running a #10 or larger copper wire from the telephone protector to the water pipe, then (b) a #6 or larger copper wire from the water pipe to the electric service grounding conductor. If the water system has less than 10 feet of pipe in contact with the earth and the electric system is not of the MGN type the telephone protector should be connected to a ground rod and interconnected with the water system and electric service ground as indicated under (a) and (b) above except that #6 copper grounding conductors should be used in connecting both to (a) and from (b) the water pipe.

5.11 For electric system grounds, the NEC (Section 250-81) states: "A metallic underground water piping system, either local or supplying a community, shall always be used as a grounding electrode where such a piping system is available." The NEC also provides that the power system ground shall consist of a connection to the water system, bonded to supplementary electrodes where the water system does not meet certain minimum requirements. These interconnections are important to the telephone installation from the standpoint of common grounding and safety. It is primarily the subscriber's responsibility to see that this bond between the <u>electric service</u> driven electrode and the water system is provided by his electrician. If the subscriber is unwilling to have this bond installed by an electrician, the telephone ground should be bonded to the power ground and the water pipe as part of the <u>telephone installation</u>. In most areas, the electric service ground and grounding conductor are part of the house wiring installation and are the property of the subscriber. It is, therefore, not normally necessary to obtain permission of the power distribution company before bonding to it.

5.12 Bonding between the electric service ground and a metallic water pipe system (suitable as a ground electrode) must have a current carrying capacity equal to or greater than No. 6-gauge copper. Such bonds should be made as short as practicable by connecting to the water pipe at the point. close to the electric grounding conductor. The grounding conductor from the telephone protector should likewise be connected to the pipe as close as practicable to the telephone protector. In this manner maximum utilization can be made of the water pipe as the bonding member in addition to its serving as a ground electrode.

5.13 During the early design state of the project, the Borrower's engineer is required to consult with the electric power company serving the area regarding joint use, use of the power system neutral for grounding telephone protectors, etc. During these conferences, the Borrower's engineer should also review the station protector grounding units covered in REA Form 511, "Telephone System Construction Contract," and obtain the power company's concurrences in the use of protector grounding units that will insure common grounding of the power, telephone, and water systems.

5.14 The design of multiple fuseless station protectors may include a common grounding bar as an integral part of the mounting. Where such a bar is furnished, 2 or more fuseless station protectors should be grounded by connecting an insulated copper wire (gauge shown in Table 1) from the ground electrode to the grounding terminal on the protector assembly.

5.15 If a common bar is not included as part of a multiple protector, or where more than one single pair protector is installed, the ground posts of 2 or more protectors should be strapped together with a No. 10-gauge insulated copper wire, and the assembly grounded using an insulated copper wire of a gauge as shown in Table 1.

6. TRAILER INSTALLATIONS

6.1 The protection of station installations in house trailers and mobile homes presents certain problems not encountered in permanent buildings. As in other station installations, it is desirable for access reasons that the station protector be installed outside the trailer. However, mounting of a protector on the trailer body is usually objectionable to the owner, and other methods must be employed. (See REA TE & CM-701, and REA Standard PC-5).

6.2 Protection for mobile homes involves the use of standard station protectors, preferably of the fuseless type where the provisions of the NEC do not require fused types.

6.3 In the preferred service entrance installation, pairs are extended by buried plant from the main distribution cable to pedestal-mounted terminal housings. A group of indoor-type station protectors or a multi-pair protector appropriate for the number of trailers to be served should be mounted in each pedestal-type housing. Each incoming pair should be connected to the protector line terminals, and connections from the protectors to the station equipment extended in accordance with REA TE & CM-701.

7. TRAILER PROTECTOR GROUNDING AND BONDING

7.1 In all station protector installations, the principle of common grounding (interconnection of the telephone ground with the power ground and local water system) is of prime importance. Because the water pipe system in trailers is frequently isolated from the main grounded water system by hose or other insulating connections, it is necessary to provide a local ground by the use of a ground rod at the protector installation. The National Electrical Code Sections 550 and 551, prohibits connection of the trailer frame or the frame of any appliance to the power neutral conductor in the mobile home; therefore, interconnection of the telephone protector ground, trailer body and water supply pipes, and power ground should be achieved as described in the following paragraphs.

7.2 Each protector ground terminal should be individually bonded to the terminal housing grounding connector with a No. 14-gauge copper conductor. The terminal housing should be grounded by means of a No. 10-gauge copper conductor to a water pipe or MGN ground if available. If neither a suitable water pipe nor a MGN ground is available, a ground rod should be driven approximately 2 feet from the pole or pedestal and bonded to the terminal housing grounding connector with a No. 10-gauge copper conductor.

7.3 The protector ground terminal should also be bonded to the trailer frame by connecting the buried service wire shield to the terminal housing grounding connector and to the chassis of the trailer with a bonding harness arrangement or an equivalent grounding connector terminal mounted with a stainless steel bolt. Details of the recommended installation are included in REA Standard PC-5.

8. AC POWER SERVICE PROTECTION

8.1 With the ever increasing use of data equipment, key systems, PABX's and other subscriber station equipment powered locally by 60Hz ac, the problem of equipment damage caused by surges on the power line is becoming more serious.

8.11 The first line of defense against this type of damage is to provide common grounding and bonding as described in Paragraph 2.3.

8.12 In severe exposure situations, however, common grounding and bonding may not provide adequate protection. Protection should then be supplemented by providing a secondary surge arrester on the ac power service to limit the magnitude of surges which can reach the equipment from the power system.

8.2 When protection of ac power service is justified, a two step approach of implementation should be employed.

8.21 As the first step, a power service protector, item "gg" on REA's List of Acceptable Materials should be installed. The power service protector should be installed as close to the ac powered telephone equipment as practicable (See Figure 2). The ground terminal of the power service protector should be connected to the power ground as discussed in Paragraph 5, of this TE & CM. Because this unit protects only the telephone equipment, its cost should be borne by the telephone company. If other than the plug in type of unit is used, the installation should be made by a qualified electrician.

8.22 If experience proves the power service protector to be inadequate, consideration should be given to the installation of a secondary power arrester. The secondary arrester should be installed at the service weather-head on the subscribers premises. Harmful surges in the power supply are first intercepted by the low voltage gas tube arrester. Surge currents through

these tubes develop potentials at the secondary power arrester sufficient to cause their breakdown by virtue of the IZ drop over the conductors. With certain types of secondary arresters, a minimum of 20 feet of steel conduit between the secondary arrester and the branch circuit panel is required to introduce sufficient inductance to cause proper operation of the arrester. The installation of a secondary arrester will protect all electrically powered equipment on the subscriber's premises. As a result, an effort should be made to persuade the subscriber or power company to pay for the installation. The secondary arrester should be installed by a qualified electrician. <u>In no case should telephone company personnel or the subscriber be expected to install the secondary arrester</u>.

8.221 Power company practices, regarding secondary arresters, vary considerably in different areas. In most cases installation of a secondary arrester at the weatherhead of the subscriber's service would require temporary deenergization of the secondary circuit serving the service. It is, therefore, essential that all installations of secondary arresters be coordinated with the power company involved. In some instances the power company may recommend that the secondary arrester be installed at the customer's load center instead of at the weatherhead. In other instances the power company may recommend the use of aluminum or plastic conduit, or possibly <u>no</u> conduit instead of the steel conduit. These alternatives are <u>not acceptable</u> because the secondary arrester must work in conjunction with the power service protector. The reactance caused by the steel conduit is essential to develop sufficient voltage drop between the secondary arrester and the power service protector to ensure operation to the secondary arrester.

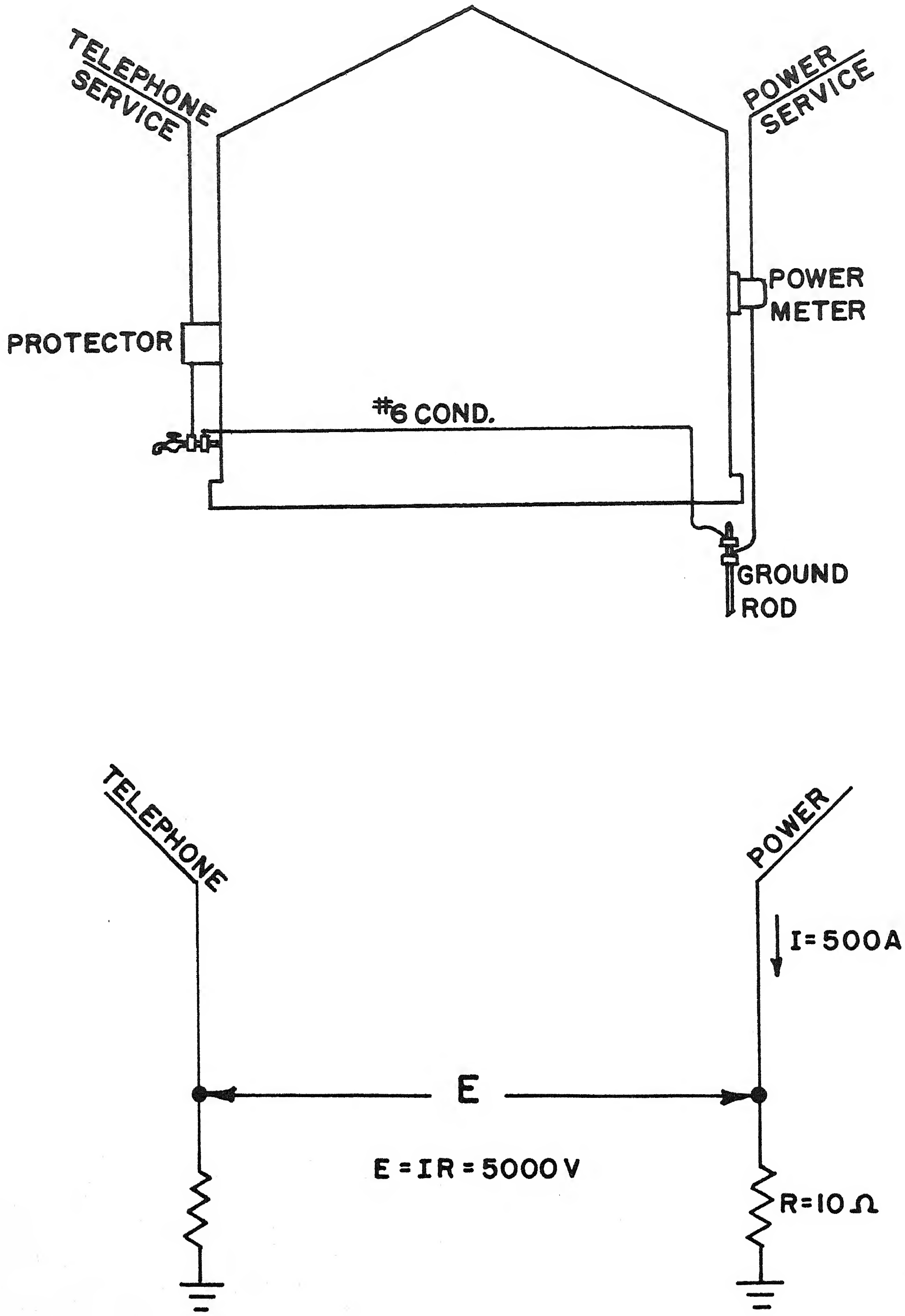

FIGURE 1: ELIMINATION OF HAZARDS BY COMMON GROUNDING

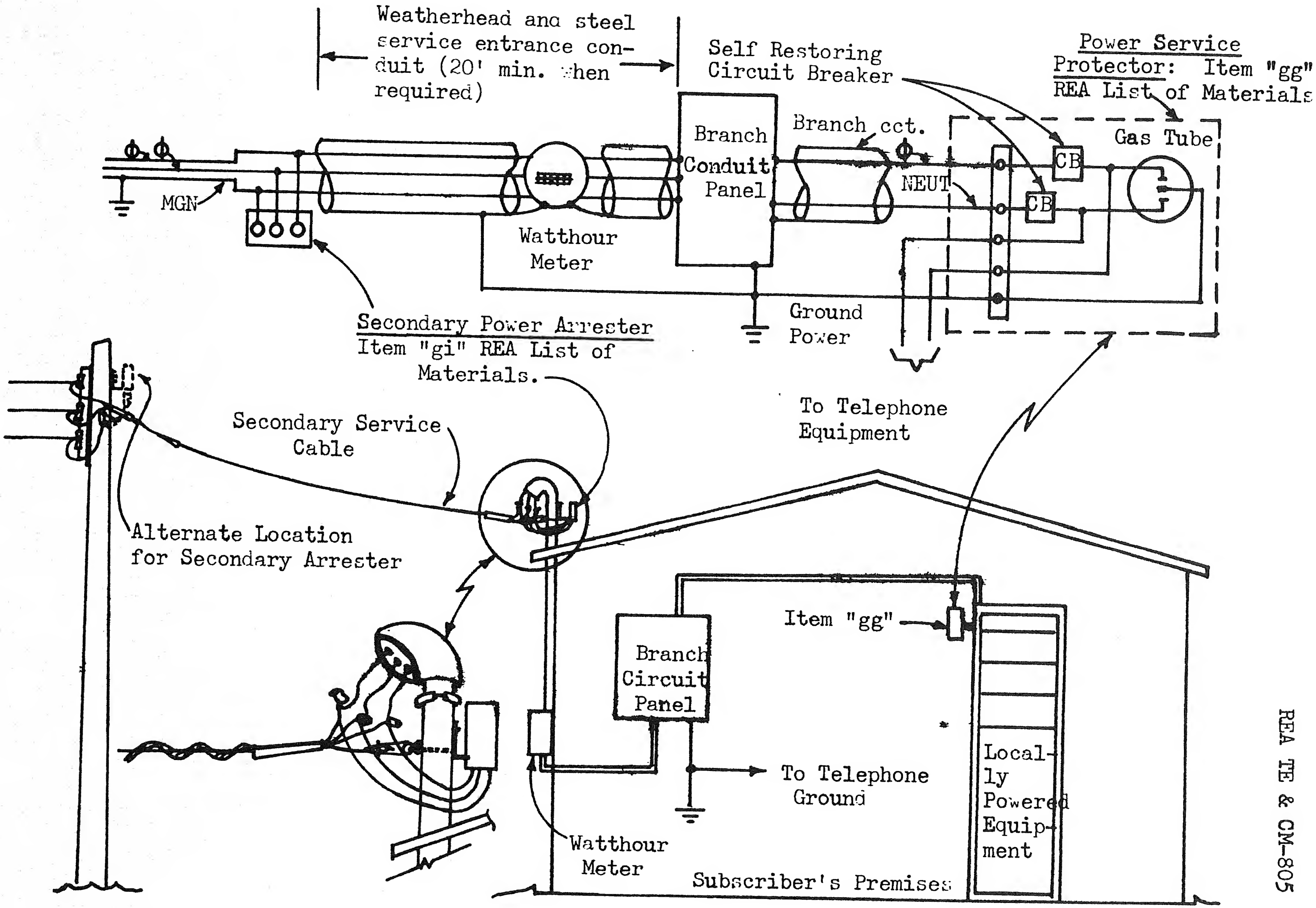

FIGURE 2: TYPICAL INSTALLATION OF SECONDARY ARRESTER AND BRANCH CONDUIT POWER SERVICE PROTECTOR